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AUTHOR	Giroux, Sylvain; Moulin, Claude; Sanna, Raffaella; Pintus, Antonio
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ABSTRACT

The term "mobile lessons" is coined for lessons held outside of "artificial" environments, such as classrooms. During these lessons, all actors are mobile and must move to do the required tasks. Themes tackled in such lessons may be as varied as geography, history, ecology, and linguistics. The use of mobile lessons is not a new teaching strategy, but new mobile devices may render it more efficient and more attractive. The aim is to place students in conditions germane to the ones in which experts work. The authors implemented in Java a software for creating and using mobile lessons and for monitoring students on the field. Contents and questions are in XML. Using this software, teachers of a high school in Sardinia (Italy) developed and experimented with a mobile lesson on the archaeological site of Nora. Under the light of this experiment, a wireless, distributed and more sophisticated version of the software is under development. (Contains 13 references.) (Author)

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Mobile Lessons

Lessons Based on Geo-Referenced Information

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Sylvain Giroux
Département de mathématiques et informatique
Faculté des sciences
Université de Sherbrooke
2500, boul. Université,
Sherbrooke, Qc
Canada, J1K 2R1
e-mail:: sylvain.giroux@dmi.usherb.ca

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Claude Moulin , Raffaella Sanna, Antonio Pintus
CRS4 (Centre for Advanced Studies, Research and Development in Sardinia)
VI Strada OVEST, Z.I. Macchiareddu
C.P. 94, 09010 Uta (CA) – Italy
e-mail: {moulin, raffa, pintux}@crs4.it

Abstract: We coined the term "mobile lessons" for lessons held outside of "artificial" environments as classrooms. During these lessons, all actors are mobile and must move to do the required tasks. Themes tackled in such lessons may be as varied as geography, history, ecology, dialects in linguistics... Mobile lessons are not a new teaching strategy, but new mobile devices may render it more efficient and more attractive. The aim is to place students in conditions germane to the ones in which experts work. We implemented in Java a software for creating and using mobile lessons and for monitoring students on the field. Contents and questions are in XML. Using this software, teachers of a high school in Sardinia (Italy) developed and experimented a mobile lesson on the archaeological site of Nora. Under the light of this experiment, a wireless, distributed and more sophisticated version of the software is under development.

Introduction

We coined the term "mobile lessons" for lessons held outside of a classroom, a science laboratory or any room situated inside the school. During such lessons, all actors are mobile and must move to perform the required tasks. Themes tackled in such lessons may be as varied as geophysics and mineralogy in geography, monuments in history, trees and ecosystems in biology, distance measuring in physics and geometry, or dialects in linguistics... Mobile lessons are not a new teaching technology or strategy, but new mobile devices may render them more efficient and more attractive. We believe that students better build their knowledge by going on the field, looking for information and by observing the real phenomenon. In other words students are put in conditions germane to the ones in which experts work. They feel more involved and must behave autonomously.

To integrate mobile devices in our constructivist "on the field" approach to learning, we designed and implemented a software we called `MobileLessons`. This software helps teachers to create lessons capitalizing on mobile devices. It also enables students to perform them on the field and finally provides tools to teachers to monitor students on the field in real-time. The implementation is in Java. Lesson contents and questions are specified in XML. The whole implementation relies on e-mate[1] (Giroux

[1] E-mate stands for Multi-modal Architecture for Telematics Environment. The E-mate project began on January 2000 and must go on till July 2002. It is held at the Centre for Advanced Studies, Research and Development in Sardinia (CRS4) and is funded by the Italian Ministry of the Universities and Scientific Research.

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et al., 2001). E-mate is a framework for the delivery of mobile personalized geo-referenced services over many channels (PCs, personal digital assistants (PDAs), cellular phones…) and using multi-modality (text, image, sound…). The platform provides distributed services over the Internet. Most of them are accessible either from a computer, a personal digital assistant (PDA), or a cellular phone. A very interesting feature of e-mate is the generation on the fly of a usable interface for any device. Some services may be either written from scratch, or may result as a composition of others. Three scenarios are illustrating the possibilities of the e-mate platform. This paper focuses on the one we called "mobile lesson".

The first release of `MobileLessons` was experimented in 2001. In the paper, we first describe the experiment of a mobile lesson, based on the exploration of a Roman archaeological site in Sardinia, Italy. In this experiment students used laptops connected to GPS. Then we present the concept of personalized course based on geo-referenced data, showing their preparation, their execution and their exploitation. Next we show how pedagogical strategies can be developed based on these lessons. Under the light of this experiment, a second release more powerful and more sophisticated of `Mobile Lessons` was developed. We present the second phase of the development of the mobile lesson infrastructure where students will use personal digital assistant connected to GPS system. In this second release, a mobile lesson is implemented as a set of distributed components called services, accessible through internet connection. We also describe briefly the system architecture which allows such services to be reached from different devices.

Experimentation

Using `MobileLessons`, teachers of a high school in Sardinia (Italy) developed and experimented a mobile lesson for the archaeological site of Nora[2]. This site is very interesting from an historical perspective because it contains both Punic and Roman ruins. The lesson was performed in June 2001 with a class of 12-13 years old students.

In the preparation of the lesson we followed two axis. The pedagogical axis addressed the lesson content itself, but also its prerequisites. In our case, some courses on the Roman civilization were necessary. These arguments were part of the pedagogical program of the class chosen for the mobile lesson. The software axis led us to build an application for both the edition of the lesson content and the management and monitoring of the students' work on the field.

While preparing the mobile lesson, teachers identified first zones of interest , then a set of hot spots for each zone (Figure 1). Hot spots correspond to precise location. Knowing the exact position of a student enables to ask precise questions on what she can see. So teachers first went to the chosen site with a GPS system and pointed out the coordinates of each hot spot. The objective was to bring students to discover these points once on the field. The information given by the GPS and associated with a position is a 2-tuple like East, 38° 59' 3,80'' ; North, 09° 00' 59,72''.

Each hot spot was then associated with other information. First a label like "the roman theatre" gives its name. Obviously, the students have to find a significant place, the theatre, and not a GPS position. But this is not enough, because the theatre is indeed a squared area whose side is more than forty meters long. The students must find the right position picked up by the teacher, near the theatre. Why the teacher chose this precise point is a question they have to answer. When some difficulties occur to find the right place, explanations, help and hints are supplied progressively. Their form may be as wide-ranging as the teacher's imagination can sustain: charade, riddle, description, etc.

Once on the field, teams of two or three students using laptops connected to a GPS system (United States Department of Defence, 1995) had to discover the significant hot spots previously identified by the teachers. They can wander wherever they want. Since the site is fenced, letting them free was not an issue. When students thought they were at the right location, the one identified by teachers, they asked the `MobileLesson` for confirmation. The current GPS position is then compared to the GPS position taken by the teacher. If the current GPS position is close enough, students have access to questions related to it. They may be general questions about the reached place but often they are questions about what the students can see from this precise location. Students have only to turn or move slightly to observe the place and discover or infer the right answers. A score was associated to each hotspot and each questions to motivate

[2] http://www.nora.it/.

the students and to give them the feeling of a game. If the position was wrong, more information about the place is supplied. Receiving it, students have to move and ask again the software if they are at the right place or not.

We used latitude and longitude to represent a GPS position. For convenience, it might be possible to transform them into UTM coordinates (Carnes, 2002) expressed in meters using a specific algorithm but for our purpose, it was not necessary. We made many tests about the precision of GPS data and we accepted a position as right with an eight to ten meters uncertainty.

What Are Geo-Referenced Data?

Mobile lessons —and the other scenarios explored within e-mate— raised for us the question of what is a geo-referenced data and they should be modelled and implemented with repect to our purposes. Geo-referenced data are information associated to a location. Data and locations may be stored in various ways, for instance in geographic information systems (GIS), in relational or XML databases, but whatever the organisation is, it must be possible to find a location from data and conversely to find all data associated to a location. For our purposes, we distinguish two types of locations: "quantitative" and "qualitative".

A quantitative location corresponds a point on the earth. For that purpose, GIS are using various kind of coordinates, but numeric values are always required. That may be a global position system (GPS) location made of two data: longitude and latitude. Longitude and latitude are angles associated with a direction. For example, the roman theatre of the archaeological site of Nora situated in the Sardinia island is located at latitude East, 38° 59' 3,80'' and longitude North: 09° 00' 59,72''.

A qualitative location is associated to a place. The concept of place depends on the semantic context. The same word may represent different places in different contexts. It may represents a sector, a city, a region, a country or anything else. For example, "Cagliari" may stand for the city, the province of Sardinia, or the island of Italy. Locations are associated with properties or predicates. The nature of the predicate depends on the location type. We can say that two GPS positions are close or not according to a precision, that a position is situated to the south of another. We may say that a city is situated in a region or not, that a country contains a region. In this sense, data and location are basically and intrinsically associated.

It is often necessary to exploit geo-referenced data to give an appropriate response to a request. The answer true or false is never enough. For instance, for the request "I am in front of the town hall of the city of Cagliari and I would like to eat a pizza", an information system must answer by a list of restaurants where pizzas are supplied and which they are located in this quarter of the city. In itself, the answer does not contain explicit information associated to locations but geo-referenced information must be exploited to get a relevant answer. If locations are associated with predicates, it is possible to make inferences based upon mathematic or semantic criteria. Naturally, it becomes necessary to organise concepts and predicates and to make inferences on them, so an ontology (Gangemi et al., 2001) is often useful to describe the semantic context of application domains.

Axis of a Mobile Lesson

Not surprisingly, mobile lesson are developed and organized along three dimensions: pedagogy, contents and technology. The next sections will describe these axis.

Pedagogical Strategies

A mobile lesson is not an isolate lesson but an element of a pedagogical sequence. It is based on previous lessons and its outcomes have to be reused in successive ones. Part of the objectives is to integrate factors that help learners to build their knowledge in a constructivist way (Dalgarno, 1998). We believe that, when it is possible, going on the field, looking for information and above all observing the real phenomenon, therefore acting in a more personal and autonomous way, are fostering the effective construction of their knowledge by students.

Obviously, these factors have to be combined to other ones like adaptability or collaboration. More generally, it is important to understand some aspects of human expertise and teaching and how tutoring systems can exploit the expertise and teaching strategies (du Boulay & Luckin, 2001). Mobile personalised and geo-referenced systems (Giroux et al., 2001) seem to be a very appropriate mean to implement such expertises (Vérillon, 2000).

Preparing a mobile lesson, a teacher selects a zone and individuates there a set of hot spots. The objective is making the students discover these points when they are on the field. Each hot spot has an associated label. So, the students are knowing that they have to find a specific place. This label doesn't indicate a point but an area and the students have to find the right position picked up by the teacher (Figure 1). A set of advice under various forms must be supplied to help students to find the right place. They are proposed gradually after no succeeding tries. When near enough, students have still to test, whether there are at the right position. The student is then bring to rebuild the same reasoning process the teacher had.

Every step necessary for discovering the right point and the use of didactic transposition (Balacheff, 1994) helps students to remember and reuse knowledge in other contexts. Generally, on an archaeological site, documentation panels are describing interesting place with many details. In order to help students find some positions (maybe the first that students naturally think of), teachers may choose points near to these panels. For other hot spots, it is better not to do so because the interesting view on the place is elsewhere or because increasing the difficulty or yielding perplexity may give an extra motivation to students.

Once found an hot spot, students have to answer questions about the place they are. It is possible for a teacher to indirectly integrate the local documentation in the course of the lesson. Students have to observe all kind of details around them for giving good answers. Mixing general questions with observation questions leads students making deduction about the behaviour of people from antic civilisation, their scientific level, their art, etc. It is also an occasion to use more than one discipline and build links between them.

Obviously, an decisive mean to motivate students (Bunt & Conati, 2001) is by making the lesson like a game. Scores are associated to discovery of hotspots and answers to questions. The less attempts are made to find a hotspot, the higher the score is. When students observe that the software decreases the value of a right answer with respect to the number of wrong attempts, a group of students is encouraged to discuss and come to a general agreement before making a proposal.

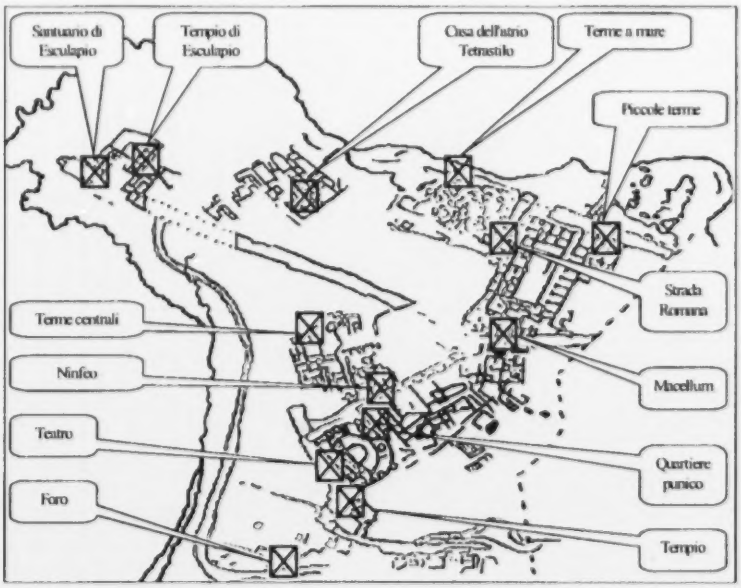

Figure 1 Hotspots chosen by teachers for the Nora mobile lesson

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Lesson Organization

Content of a mobile is at the center of the four steps of the lifecycle of a mobile lesson: design, presentation, execution and exploitation.

First step: design of the lesson.

Obviously first teachers design the lesson and prepare the pedagogical material. A synopsis is made defining the theme and the objectives. A site is identified. Then teachers go on the site and identify important places and prepare location-based questions (Figure 2). They use `MobileLessons` running on a mobile computer (laptop, PDA, or mobile phone) equipped with a GPS system and connected to Internet if necessary. Finally, teachers prepare help and hint that students might receive and complete lesson description. During this step, documentation is built and referenced and a scenario that describes the tasks to complete is elaborated.

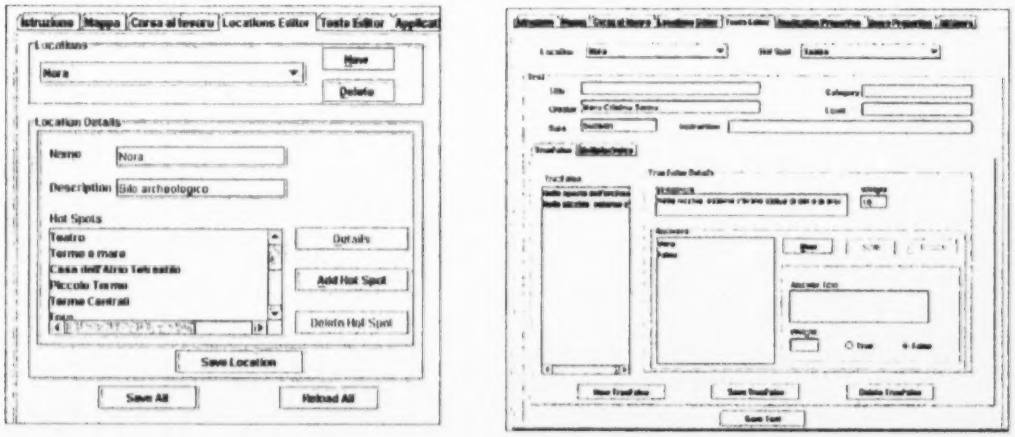

Figure 2 Hotspot editor and questions editor.

Second step: presentation of the lesson.

Once the lesson is ready, teachers present it to the class. They show the map of the site, present the tasks to do, and show also how to manipulate the devices and software. They also have to build the students' groups. The lesson is made in teams of two or three students.

Third step: lesson execution.

Then students go on the field under the responsibility of teachers. They have to follow the lesson scenario and find the places pointed out by teachers (Figure 3). They may have to find them following a precise order (different for each group) or not. Depending on the lesson theme, they have to observe monuments or site details, take notes, find minerals or vegetal, answer to questions using the help of documentation, take photo, etc. They may also have to measure things on the field as if they were scientists in a real context. If software allows it, teachers can follow the path of every group on the site map (Pfoser & Jensen, 2001). It is possible to track them if every computer sends regularly its position to a remote service.

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Fourth step: course exploitation.

The class analyses data picked up on the field and reports can be done. Teachers may add also every kind of explanations and give general synthesis.

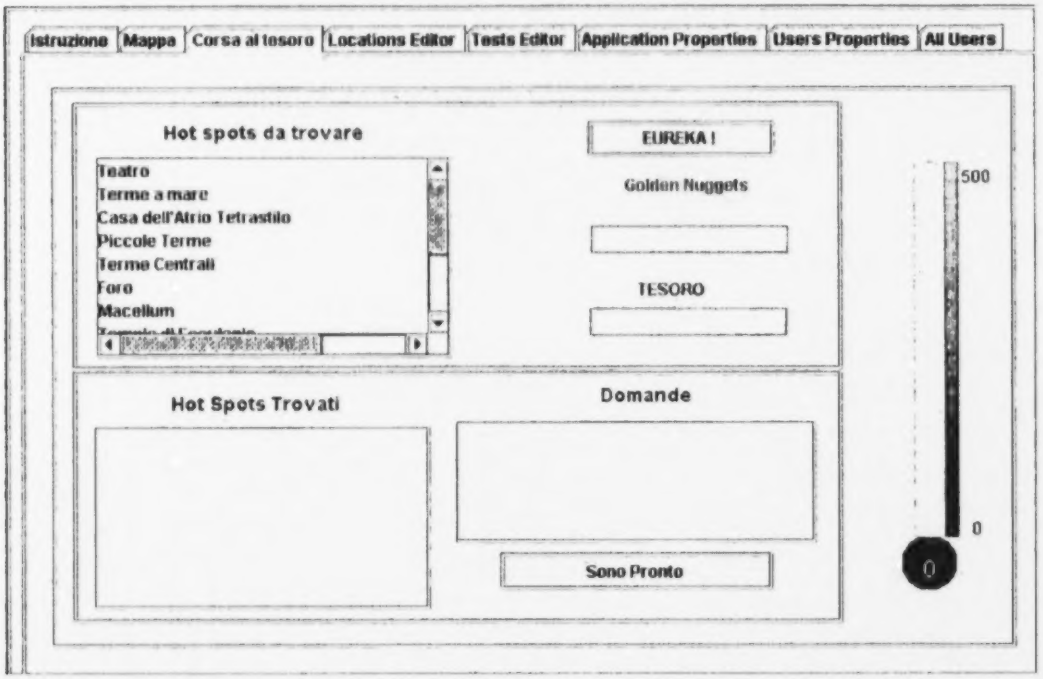

Figure 3 : Panel that the students use to participate to a mobile lesson.

Technology

For the experimentation describes in this document, we prepared an autonomous software for supporting the lesson. We built an unique application installed locally on each laptop used by students. Lesson data were also stored on computer. The main problem for students is to move on a sunny site with a device which is a bit heavy, that requires many precautions and upon which it may be difficult to read due to the sun. Nevertheless, this experimentation was absolutely necessary for testing all elements of the lesson.

Encouraged by this success we designed the mobile lesson as a scenario of the e-MATE project. It uses the general infrastructure we built to deliver on-line services. Software and devices used on the field are completely different but the content itself of the lesson remains the same. We also integrated results of the experimentation and comments of all actors involved in the process to improved the way of presenting data and we added modules not implemented previously. Students on the area of the lesson, are now using a PDA. Only a part of software is installed on it and assures all connections with the school web site and the remote part. The PDA is equipped with a GPS system that automatically gives its position coordinates. This position is transferred to the remote architecture and so the service can detect if a student is facing an hot spot of the lesson or not.

We can define the mobile lesson e-learning service as a distributed software application, that delivers an adapted geo-referenced information on request. Figure 4 gives the architecture of the system that support the mobile lesson. Only a part of the service is loaded on it, the terminal tier. As several PDA

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are simultaneously connected an HTTP server is required to manage for each device the remote tier of the service. It find its resources in the application server that deployed it. The HTTP server itself finds the remote tier of services required by the users in the service portal where the application server has published them after their deployment. Data exchanged (Zhang, 2000) between PDA devices and the HTTP server is contained in an XML document (XML, 2000).

E-mate architecture is a software architecture aimed to support the development of Mobile Personalised Location based Services (MPLS). It defines a model of services and provides a framework that facilitates the deployment of new position-aware services available through multiple channels. Distributed systems supply for a conceptual framework for building efficient and secure distributed services (Coulouris et al., 2001). E-mate addresses both the heterogeneous nature of access and the management of user sessions.

The architecture contains three main elements: The application server, the service portal and the service viewer. The application server deploys new services and publish them into the service portal. Deploying new services means launching the server session of a service. It is a part of a service which runs on the same workstation that the application server and even if no users are connected to the service. The application server also publishes services. It consists in storing a piece of each service into the service portal, the part that moves dynamically to any client that requires the service (the remote tier in the above example).

The service viewer is the user entry point in the system. For personal computer, it is an autonomous application that runs on it. For PDA, it is composed of two parts, due to the fact that they cannot dynamically load code: a local one and a remote one. After the user identification, it looks for the services published on the service portal. Then the user chooses the service with which working.

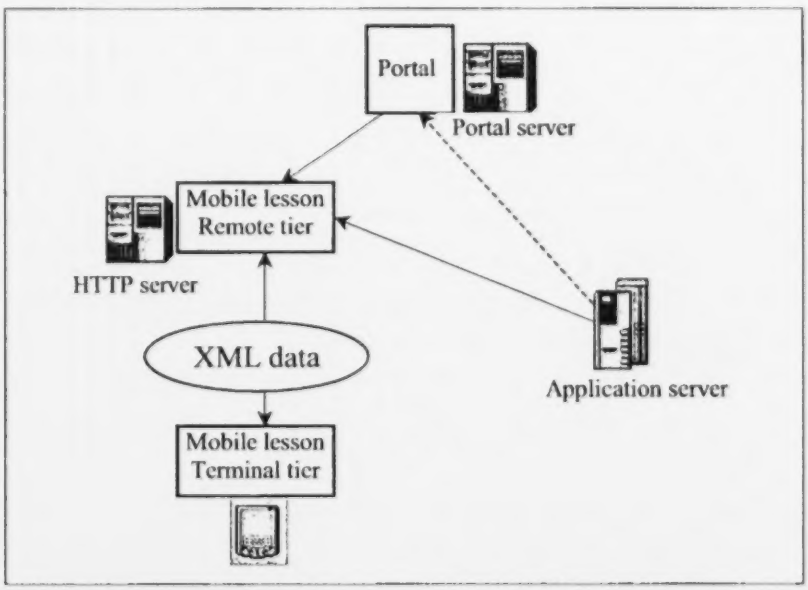

Figure 4 Communication in the case of distributed architecture.

Conclusion

A mobile lesson is the combination of three complementary axis: pedagogy, content and technology. Teachers are in charge of the preparation of the lesson itself and its contents, and computer scientists are responsible for the preparation of software to support the lesson on the field. Our experimentation proved the feasibility and the interest of mobile lessons. The involvement of teachers in the preparation of the lesson and pedagogical documents was critical and we are very grateful to them. The

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application we built for editing documemts and for the execution of the lesson itself, was robust enough to avoid any problem on the field. The sattisfaction of everyone and the desire of going more deeply in the experience tell us that it was a success.. Besides its first objectives, a mobile lesson such as the one we described in this paper lead students to develop their own learning strategies. As our main conclusion, we can claim that associating various types of information, proving, succeeding, failing and trying to understand why, in a playful and motivatting way, are surely among the best ways to acquire knowledge.

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